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THE CONTROL OF STAIN, DECAY, AND OTHER SEASONING DEFECTS IN RED GUM

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COOPERATIVE STUDY OF LOSSES IN LOGS AND LUMBER

Stain, decay, and other seasoning defects in both logs and lumber have been the source of such serious losses in the manufacture of southern hardwoods that in 1924 the Southwestern Hardwood Manufacturers' Club requested the cooperation of the Forest Products Laboratory in a special study of the losses and of the means to reduce

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ACKNOWLEDGMENTS.—Without the cooperation of members of the Southwestern Hardwood Manufacturers' Club and other southern red gum manufacturers who contributed funds and otherwise assisted in the work, this study would not have been possible. The laboratory is doubly indebted to the mills which made available their plant facilities and provided labor and material for the practical tests carried out in the course of the investigation.

The cooperating companies were the following: S. T. Alcus & Co., New Orleans, La.; Sherrill Hardwood Lumber Co., New Orleans, La.; Lucas E. Moore Stave Co., Mobile, Ala.; J. M. Jones Lumber Co., Ferriday, La.; Hillyer-Deutsch-Edwards (Inc.), Oakdale, La.; South Texas Lumber Co., Houston, Tex.; W. R. Pickering Lumber Co., Haslam, Tex.; Brewer-Nienstedt Lumber Co., Palmetto, La.; Kraetzer Cured Lumber Co., Greenwood, Miss.; Newell Lumber Co., Eunice, La.; Angelina Hardwood Lumber Co., Ewing, Tex.; Faust Bros. Lumber Co., Jackson, Miss.; Martin Wagon Co., Lufkin, Tex.; Peavy Moore Lumber Co., Shreveport, La.; Lyon Lumber Co., Garyville, La.; Frost Lumber Industries (Inc.), Shreveport, La.; Baxter Forest Lumber Co., Meridian, Miss.; Soniat & Deblieux (Inc.), Opelousas, La.; Louisiana Central Lumber Co., Clarks, La.; Arkla Lumber & Manufacturing Co., Plaquemine, La.; Jasper County Lumber Co., Jasper, Tex.; Tremont Lumber Co., Rochelle, La.; Latt Lumber Co., Colfax, La.; Stout Lumber Co., Thornton, Ark.

Valuable assistance was also rendered by the Crossett Lumber Co., Crossett, Ark.; the Utley-Holloway Sawmill Co., Clayton, La.; and J. F. McIntyre & Sons, Pine Bluff, Ark.

The writer makes full acknowledgment of the work of A. C. Knauss, formerly engineer in forest products at the laboratory, who started the study, did most of the field work, and collected most of the data used in this circular. Valuable assistance in the preparation of the manuscript was rendered by the Madison branch of the office of forest pathology.

them. It appeared that a survey of log and lumber storage in the southern hardwood area would be the most practical means of getting at the causes and extent of the losses and that the problem of preventing the losses could be attacked most effectively through field experiments.

Accordingly, A. C. Knauss, an engineer of the laboratory staff, was detailed to the project in June, 1925. After Mr. Knauss's resignation from the service in September, 1925, the work was taken up by the writer and brought to the present stage of completion. As it was impossible, within the scope of the study undertaken, to investigate losses in all the southern hardwoods, it seemed advisable to confine the immediate effort to red gum (*Liquidambar styraciflua*), the sapwood of which deteriorates very rapidly in the log and only too often in the form of lumber during yard-drying.[1]

CAUSE OF BLUE STAIN AND DECAY

To control stain and decay it is necessary to know the conditions favorable and unfavorable for their development and to eliminate as many of the favorable and produce as many of the unfavorable conditions as is economically practicable.

Blue stain is caused by the growth of certain species of fungi. These fungi produce minute bodies called spores, which function in about the same way as the seeds of higher plants. The spores are constantly present in the air, and when they settle on the surfaces of freshly cut sap boards or on the freshly cut ends of logs, other conditions being favorable, they begin to grow and to produce microscopic threads which penetrate the wood. These threads may spread to other wood that may have been protected from the initial infection. Stain can also enter logs through abrasions in the bark. Plate 1 shows a typical log-storage area in the woods. The bark on the logs shown in this illustration has been bruised or stripped away in the course of handling.

Blue-stain fungi feed principally on the contents of the wood cells in the sapwood and do practically no damage to the wood fiber. The objectionable bluish appearance is the combination of the light color of the wood and the dark color of the fungus threads in the wood.

Decay, or rot, is caused by an entirely different group of fungi. These fungi, however, act in much the same way as the blue-stain organisms; that is, they get into the logs and boards by spore dissemination or by contact, and grow in the wood cells. All decay fungi consume the wood substance, and in so doing they destroy its strength and usefulness. In the case of sap gum, decay usually changes the color of the wood to a whitish yellow.

CONDITIONS AFFECTING DEVELOPMENT OF FUNGI

The conditions that favor the development of blue stain also favor the development of the fungi that cause decay. Fungi grow most rapidly when the temperature is about 80° to 100° F. As the temperature falls their rate of growth decreases, and at temperatures of 40° to 45° their growth practically stops. This is the chief reason why stain is lacking in winter-cut logs, whereas summer-cut logs stain rapidly. For the same reason less stain is encountered in northern logging operations than in southern. As the temperature rises above 110° the growth of the fungi again decreases; and tests have shown that at temperatures above 125° to 130° the fungi are killed, if the temperature is maintained for a sufficient length of time.

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[1] In manufacturing red gum logs into lumber the sapwood is usually separated from the heartwood, the sapwood being referred to as " sap gum " and the heartwood as " red gum." The same method of designation will be followed in this circular.

Other conditions being favorable, blue stain and decay-producing fungi will develop when the moisture content of the wood surface upon which the spores settle is within certain limits. A minimum moisture content of approximately 20 per cent of the weight of the dry wood is required to sustain growth. If the surface dries below that point the fungi stop growing, although they may remain alive and will begin growing again if the surface becomes moist enough and other conditions are favorable. On the other hand, if the supply of air, which is necessary to the fungi, is cut off by keeping the wood thoroughly wet, they can not develop. This explains the protection afforded against stain and decay by keeping logs immersed in water.

In a healthy red gum tree the moisture content of the sapwood is very high, and after the tree is felled fungous spores do not develop on the freshly exposed sapwood until some drying has taken place. Since the heartwood is naturally more resistant to fungi than is the sapwood, the log end as a whole remains immune for a short time. Fresh boards leaving the saws at the mill are not infected until a certain amount of drying has taken place. The surfaces are practically running with water, and as long as they remain in this condition they are almost completely immune to stain.

After the free water evaporates from the exposed surfaces, the moisture in the outer cells begins to leave and is replaced by air. In this state of the surface the spores will develop and spread into the cells that have partly dried. At first only a thin outside layer is dry enough to permit development, but the infection gradually extends deeper and deeper as the stain organisms follow the progress of the changing moisture line. This is well illustrated by the manner in which stain penetrates the ends of logs. One week after cutting, the log end shows only surface stain; in three weeks the stain may have penetrated 18 inches; and in three months it may be 4 to 6 feet it from the ends. Although the conditions that are favorable for stain are also favorable for decay, the decay organisms do not develop as rapidly as the stain organisms. Where stain has penetrated into a log 2 feet, decay may show for only 6 inches.

CHECKING AND OTHER DEFECTS

Logs and large timbers check more or less severely at the ends after drying begins, because the wood shrinks more along the annual rings than radially or at right angles to the rings. Also, in red gum it is characteristic of the heartwood to shrink more and therefore check more than the sapwood. Plate 2, A and B, illustrates this characteristic, the logs having prominent star checks in the heartwood and fine, scattered checks in the sapwood. An exaggerated case of checking, in oak, is shown in Plate 4, C. End-checking is seldom serious enough to cause appreciable waste when the logs are cut up, but it is objectionable in that the checks that form in the log, particularly in the heartwood, usually extend farther into the board during the seasoning process. End-checking in the sapwood is also objectionable because it offers a favorable place for the entrance of stain and decay organisms.

Sap gum lumber in thicknesses up to 6/4, either plain or quarter sawed, may be dried rapidly without much danger of surface-checking; but 8/4 and thicker stock must be handled carefully or the checking may become serious. The heartwood, or red gum, will surface-check readily under conditions of drying that would not cause checking of the sapwood. Consequently, if the proportion of red gum present with sap gum is high, the stock should be handled as red gum. It is also characteristic of gum lumber, both heartwood and sapwood, to warp and twist during the seasoning process unless proper precautions are taken.

PREVENTING STAIN, DECAY, AND CHECKING IN LOGS

IMMEDIATE CONVERSION

The best way to avoid blue stain, decay, and other defects in gum logs in warm weather is to get them into the mill within a short time after felling. At some of the mills visited in the course of the survey the logs were brought in within a week or less after felling, and in such cases the logs were practically free from any stain or decay. Logs left longer than a week began to show stain, and those left for upwards of three weeks often showed decay as well.

At one of the mills visited the logs had been cut between July and December of the previous year, with the expectation that they would be rafted out during high water in February. Lack of water prevented rafting, however, and finally the logs were brought in by rail. Although the heartwood was sound, the sapwood was stained throughout, and the ends of the logs were badly decayed. These logs did not produce a stick of upper-grade sap lumber, and in addition there was a heavy loss when boards were trimmed to cut off end rot.

CHEMICAL TREATMENT OF LOGS; END COATINGS

Few manufacturers find it possible either to convert their logs immediately or to keep them in continuous water storage before milling. Some operators must wait for high water to raft out the logs, others can not get at their logs during periods of high water. In either case it may be necessary to store logs in the woods for weeks or even months. At many mills it is necessary, for one reason or another, to carry a large stock of logs in the yard. For logs that must be stored there are a number of possible treatments that will aid in resisting the development of the stain and decay organisms for a considerable period.

It has been known for some years that applying suitable antiseptics to the freshly cut ends of gum logs that were to remain in storage would prevent deterioration due to stain and decay. In 1907 Von Schrenk[2] reported successful experiments with hot coal-tar creosote.

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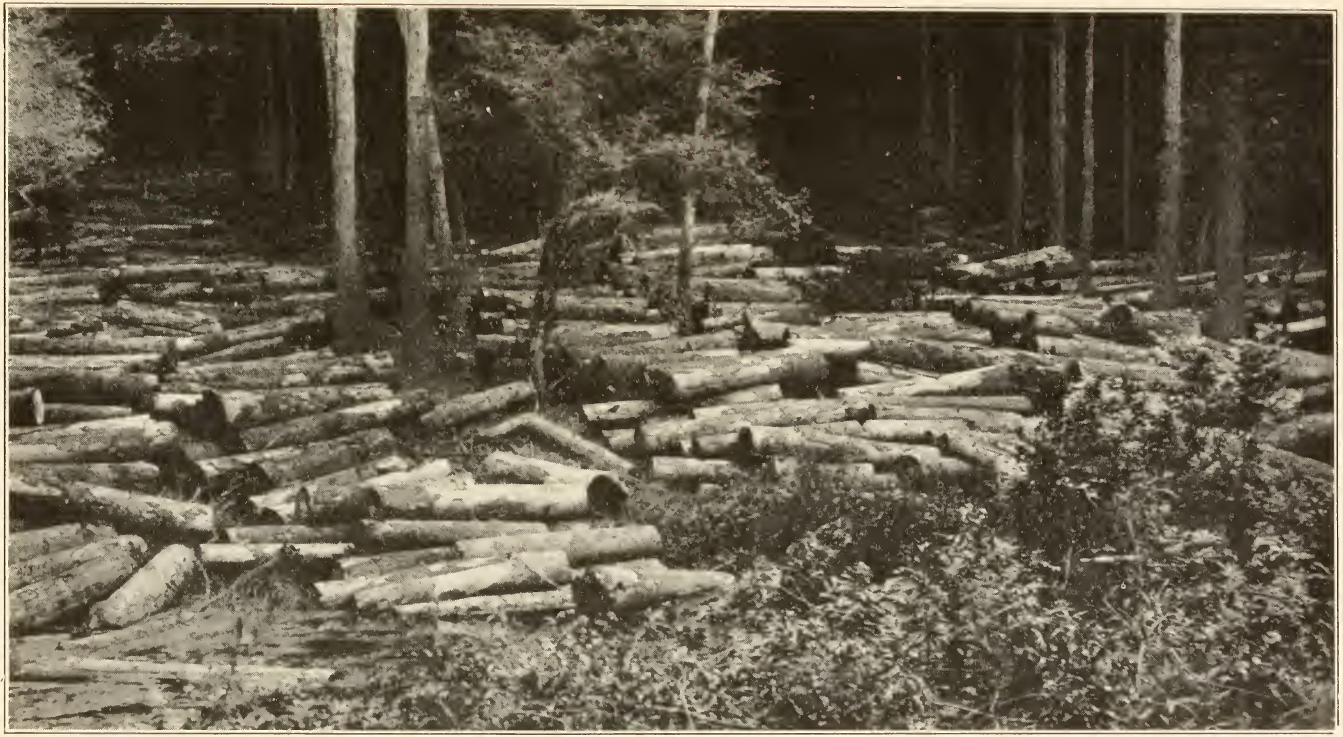
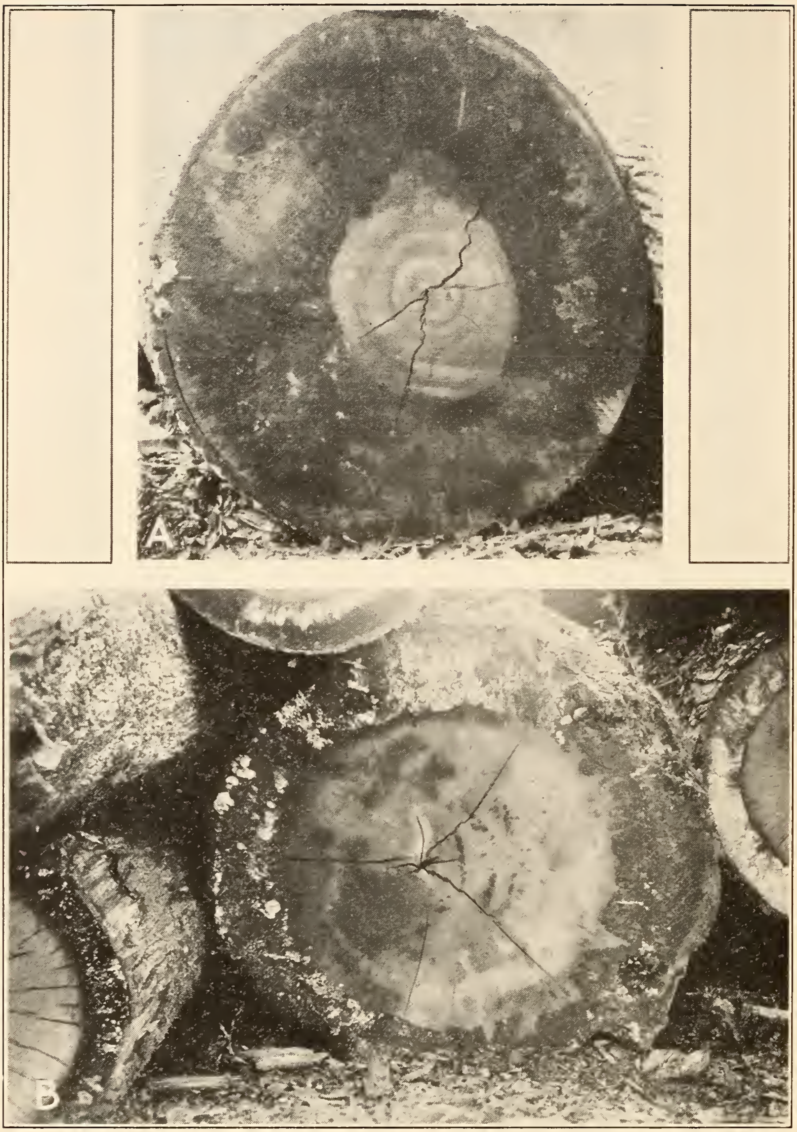
[2] SCHRENK, H. VON. SAP-ROT AND OTHER DISEASES OF THE RED GUM. U. S. Dept. Agr., Bur. Plant Indus. Bul. 114, 37 pp., illus. 1907.



GUM LOGS YARDED IN THE WOODS

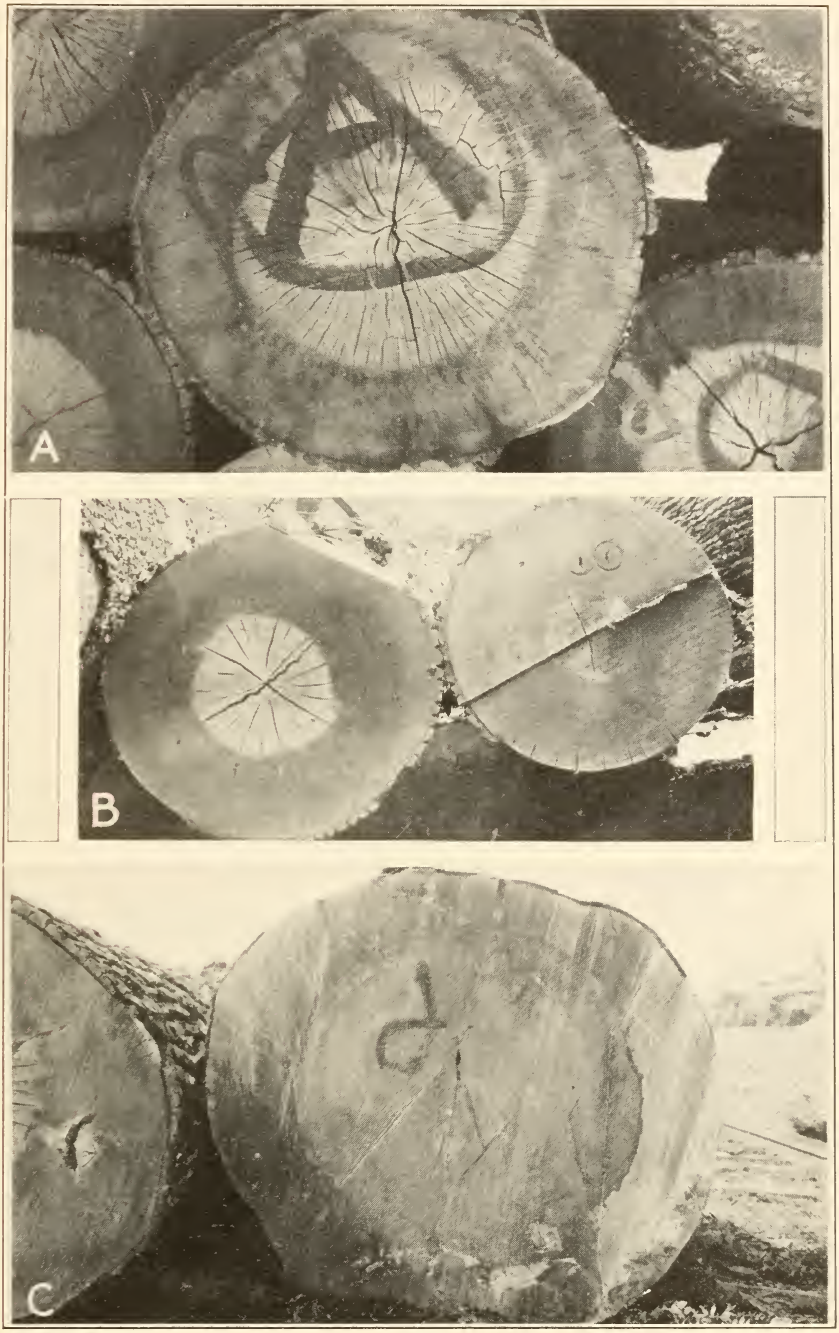
Large areas of the bark have been knocked off most of these logs providing an easy entrance for stain organisms. Spraying the sides of the logs will protect these bare spots to some extent



RESULTS OF STORING UNTREATED GUM LOGS

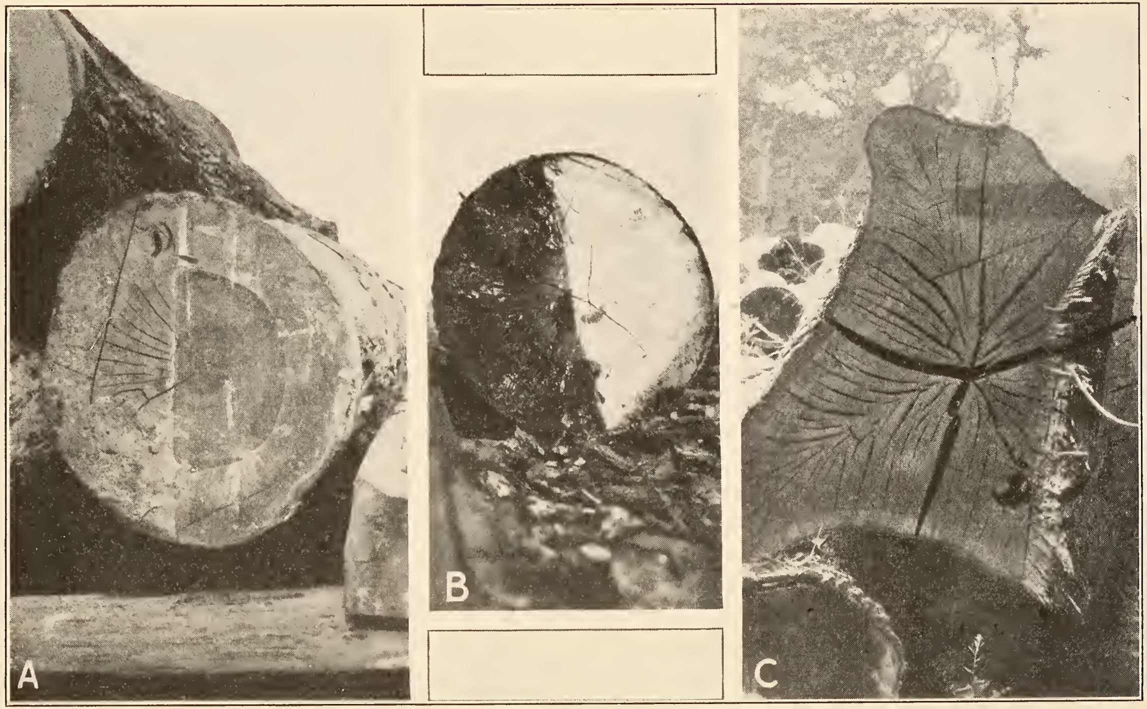
A.—After about a month in the woods checks are developed in the heartwood and stain fungi are abundant on the sapwood

B.—After six months in the log yard of a Louisiana mill the sapwood of these logs is badly decayed



EFFECTS OF PRESERVATIVE TREATMENT ON GUM LOGS

A.—A gum log sprayed with cresylic acid and kerosene in June and left in the woods for a month shows greatly reduced stain and decay, even though large checks in the heartwood and numerous fine checks in the sapwood have not been prevented. B.—After five weeks in the log yard (June and July, 1925) gum logs end-coated with unfilled hardened gloss oil and cresylic acid were slightly freer from stain and decay than logs treated with cresylic acid and kerosene, but were quite as badly checked. C.—Filled hardened gloss oil and cresylic acid as an end-coating has been very effective in reducing the development of stain, decay, and checking in tests synchronous with (B)



CONTRAST OF TREATED AND UNTREATED WOOD

The right half of the logs in (A) and (B) was end-coated with filled hardened gloss oil and cresylic acid, the left half untreated. After five weeks in the woods during June and July (A) is free of mold and end checks on the treated half and has practically no stain below the treated surface, although all three defects have deteriorated the untreated portion. Even more strikingly (B) is practically free of checks in the treated side, but the untreated half has developed numerous checks and has suffered serious inroads from decay. C—An end coating of filled hardened gloss oil would undoubtedly have reduced very materially the checking in this oak log only a few weeks felled

More recently Loughborough and Hubert[3] discussed the problem of end treatments and recommended certain mixtures for the purpose. In the present field experiments three such mixtures were tested. The first two were suggested by Loughborough and Hubert, and the third was a modification of the second. The formulas were as follows (all proportions by weight):

No. 1. Cresylic acid, 1 part; kerosene, 10 parts.
No. 2. Cresylic acid, 1 part; hardened gloss oil, 10 parts.
No. 3. Cresylic acid, 1 part; filled hardened gloss oil, 10 parts.

These mixtures are easy to prepare. A container of ample capacity is put on the scales and its tare determined. The cresylic acid is poured in and weighed. The beam is then set for the additional weight required by the formula used and is brought to a balance by pouring in the second liquid specified. More or less stirring may be necessary.

Cresylic acid is a mixture of the three monomethylated phenols and is one of the cheapest commercial antiseptics. It may be obtained from manufacturers of and dealers in coal-tar disinfectant and insecticides. In the first mixture kerosene was used as a vehicle. Crude oil, if available, may be used instead of kerosene with practically identical results and less expense. This mixture can be applied with either a hand or a power sprayer of the type used in greenhouses and orchards.

Hardened gloss oil is a cheap rosin varnish made up of 100 parts rosin, 8 parts quicklime, and 57.5 parts naphtha, by weight. It may be obtained ready mixed from paint manufacturers. It was used in the second mixture to retard the evaporation of the cresylic acid and to reduce, if possible, end-drying and checking of the log. In the third mixture, to provide a more positive means of reducing end drying, there was added to the hardened gloss oil a cheap inert pigment consisting of 25 parts asbestine and 25 parts barytes to each 100 parts gloss oil, by weight. The asbestine helps to prevent the settling out of the barytes. The gloss oil when so treated is called filled hardened gloss oil. Both hardened gloss oil mixtures are applied with a common paintbrush. They are of about the consistency of thick, heavy varnish and are transparent enough not to conceal the end grain from the sawyer when the log is being cut up.

Betanaphthol might be substituted for cresylic acid in the above mixtures but is somewhat more expensive. It has many times the antiseptic value of cresylic acid, however, is less volatile, and will not leach out of the wood so quickly. Its use would probably result in longer periods of protection, particularly for logs that might be alternately wet and dry.

FIELD TESTS

A quantity of each mixture was sent to 10 mills with instructions as to the method of application. At each mill 32 freshly cut logs were selected for the test. Eight logs were treated with each mixture, and eight were left untreated. The logs were stored either in the woods or at the mill until the laboratory representative arrived at the plant. Most of the logs were treated early in June, 1925, and were cut up five to eight weeks afterwards.

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[3] LOUGHBOROUGH, W. C., and HUBERT, E. E. PROBLEMS IN THE SEASONING OF SOUTHERN HARDWOODS. South. Lumberman, 117: 170–174, illus. 1924.

When cut up, the sapwood of the untreated logs showed an average staining of about 2 feet at each end, and in some logs the penetration was as much as 4 feet. In many cases, also, decay had set in at the ends.

For the period of eight weeks of summer weather covered by the tests, the cresylic acid-kerosene spray treatment totally inhibited surface molds and materially reduced the end penetration of the stain. Logs stored five weeks were stained for about 4 inches from the ends; those stored eight weeks, as much as 12 inches. Apparently this treatment will confine the stain, during a period of three to four weeks, to wood that is ordinarily trimmed off at the mill. After that period the logs should be converted or the treatment repeated. Just what could be expected from repeating the spray treatment once or twice during the first six weeks of storage is unknown, but there is reason to believe that the results would justify the labor and expense when logs are to be stored for two or three months of summer weather.

Plate 3, A shows a red gum log which was sprayed with a cresylic acid and kerosene mixture and held in the woods for about one month. Compare the bright, clean condition of this log with the moldy condition of the untreated log shown in Plate 2, B. Large checks in the heartwood and a multiplicity of fine checks in the sapwood are characteristic of both sprayed and unsprayed logs, with no apparent difference in the intensity of the checking in the two cases. End-checks in the heartwood are important in so far as they cause waste in trimming the lumber at the sawmill. The checks in the sapwood are usually too fine to cause waste by trimming but are important in their relation to the spread of stain and decay organisms. Even in untreated logs the surface may dry below the critical point before these organisms can develop, and on the surface of sprayed logs their growth is prevented by the cresylic acid; but the fine checks, penetrating through the outer zone of safety, offer an opening through which fungous spores can reach the unprotected wood. The expectation in repeating the spray treatments at intervals of about three weeks would be that the antiseptic would penetrate the checks and form a new zone of protection.

The second mixture, made up of cresylic acid and hardened gloss oil, was somewhat more effective as an antiseptic than the cresylic acid-kerosene mixture, the stain penetrating only about 2 inches in the logs stored five weeks and 6 to 12 inches in those stored eight weeks. It was not effective in preventing end checks because it lacked body. (Pl. 3, B.)

The third mixture, made up of cresylic acid and filled hardened gloss oil proved very effective, almost entirely elminating both stain and end checks even where the logs were stored for eight weeks. The addition of the filler makes this mixture very effective in preventing end drying, thereby preventing end checking. The beneficial result of adding the filler can be clearly seen by comparing Plate 3, B and C. The hard surface exposed is also a mechanical barrier against infection. Plate 4, A and B shows red gum logs having one-half the end coated with the mixture of cresylic acid and filled hardened glass oil, the other half uncoated. The coated portion is free from checks in the sapwood and practically so in the heartwood. In the uncoated portion many large checks are visible in the heartwood; also, numerous fine checks were noticed in the sapwood, but these are largely obscured in the pictures by the heavy growth of mold.

CHECK TEST

About August 20, 1925, in order that the results of preservative treatments over a longer and later period of the year might be determined, 24 freshly cut logs were treated with mixtures similar to those in the first test. Kerosene was replaced by crude oil in the first mixture, the proportions being cresylic acid 1 part, crude oil 10 parts. This mixture was applied with an ordinary greenhouse hand sprayer. Plain hardened gloss oil mixture was eliminated from the test, as it had proved less effective against both stain and checking than the filled hardened gloss oil mixture. Ten logs were given a brush treatment on the ends with the filled hardened gloss oil mixture and 10 were given the spray mixture on the ends, while four logs had one-half of the end surface treated and the other half untreated. All of these logs were sprayed over the bark with the spray mixture. Some of the logs were treated the day they were cut and the rest seven days later, the object being to get some idea of how soon after cutting the coating should be applied. Five untreated logs were stored with the treated logs for comparison. All logs were stored in the woods for about three months, until November 26, when they were brought in to the mill. They were cut up on November 27. Numerous heavy rains occurred during the time they were held, and for part of the time some of the logs were under water. Although it was late in the year and the weather cool, particularly during October and November, the temperature range was generally favorable for stain and decay.

RESULTS OF CHECK TEST

The untreated logs were stained 3 to 4 feet in from the ends and from 2½ to 3½ inches deep around the log under the bark. Decay had penetrated into the ends an average of 12 inches, with occasional fingers extending inward 18 inches.

The logs sprayed with cresylic acid-crude oil mixture on sides and ends the day after they were cut were stained 2 to 8 inches in at the ends, with fingers extending inward 12 to 18 inches. Occasional streaks of stain had penetrated under the bark to a maximum depth of 1 inch in the sapwood. The same mixture applied a week after felling proved somewhat less effective, as the stain penetrated deeper at the ends and through the bark. These results indicate that the logs should be treated within a day or two after felling.

The logs treated with cresylic acid and filled hardened gloss oil were as a rule in slightly better condition as regards stain than those treated with the cresylic acid-crude oil mixture, but a few were stained deeper. It appeared that the poorer results, which were exceptional, occurred in logs which had been submerged long enough for the end coating to become softened and partly washed out, so that an easier entrance for the stain was afforded.

SUMMARY OF LOG TESTS

The mixture of cresylic acid with crude oil or kerosene proved very effective in preventing stain for nearly three weeks during warm, dry summer weather or for three months of wet fall weather. The filled hardened gloss oil-cresylic acid mixture gave somewhat better results in both instances.

Stain that was found in treated logs was of a lighter color than that in the untreated logs. This is illustrated in Plate 5, which shows a short length cut from a board taken from a log one-half of the end of which had not been treated and the other half of which had been treated with filled hardened gloss oil. In the treated area the stain penetrated about 7 inches and was very light in color, whereas in the untreated area stain of a much darker color had penetrated about 3 feet, and fingers of decay had extended inward about 18 inches from the end.

Decay was observed in the untreated logs of both original and check tests, but no decay was observed in any of the treated logs. All three treatments tried were successful in preventing decay throughout the periods of test and would probably be effective in resisting it for a much longer period.

End checking was practically eliminated as a source of damage by the use of the filled hardened gloss oil. The effectiveness of this coating in the tests demonstrated its value as an end coating for ties, timber, and thick yard stock, in which serious end checking is of common occurrence.

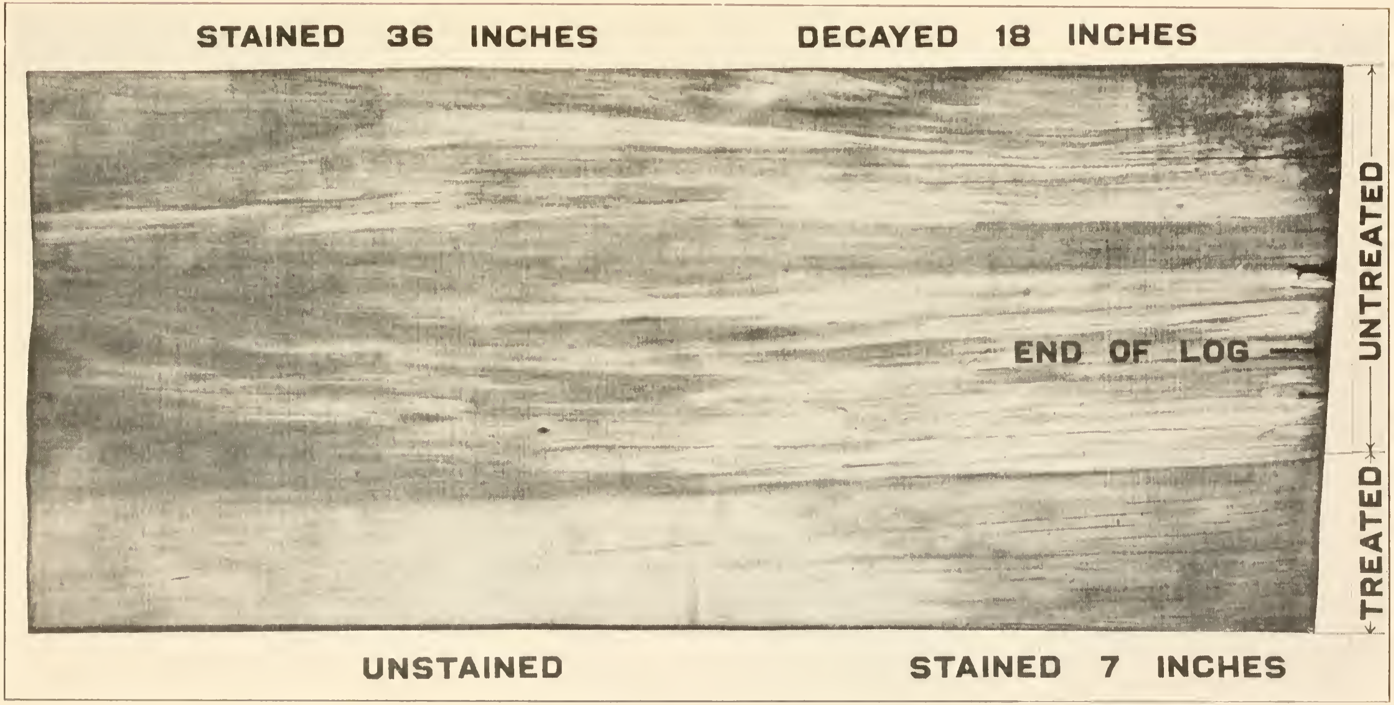
COSTS

The cresylic acid-crude oil mixture for spraying the sides and ends of logs costs about 15 cents a gallon or 5 cents per thousand feet, log scale. The cresylic acid-filled hardened gloss oil mixture costs about 60 cents a gallon. It is applied with a brush to the ends of logs and 1 gallon will coat the ends of 10 or 12 logs averaging 2 feet in diameter. The labor cost for the application of either mixture ranges between 2 and 5 cents per log.

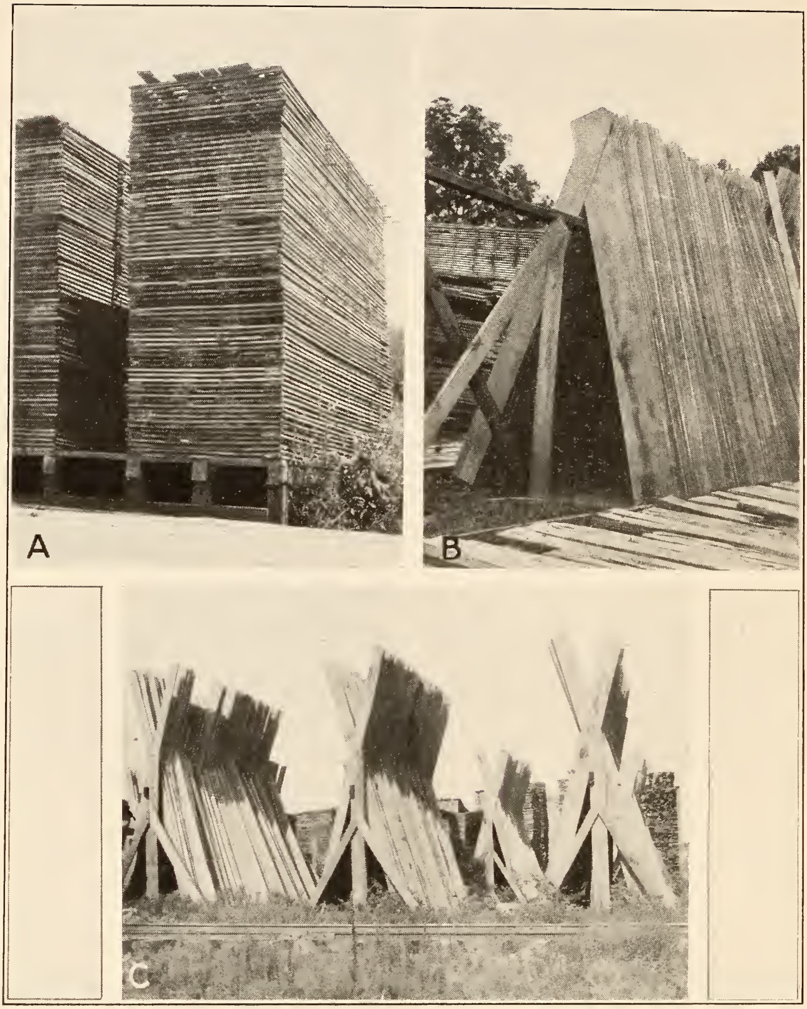
PREVENTING STAIN, DECAY, AND OTHER DEFECTS IN LUMBER

The second phase of the field experiments had to do with the problem of the seasoning of sap gum lumber.

On the basis of the present hardwood grading rules stain is not considered a defect in sap gum because it does not appreciably reduce the strength of the wood. Inasmuch as severe stain is frequently associated with decay, however, the consuming trade is very suspicious of stained lumber. Consequently bright lumber sells not only more easily than stained lumber but often at a premium. In the course of these field experiments orders were noted in which premiums of $4 to $8 per thousand board feet were being paid for bright sap gum lumber. An additional advantage of bright lumber is that it is easier to grade. Although some of the manufacturers interviewed stated that they found it just as easy to sell stained stock as bright stock, such cases were exceptional, and the impression of



Penetration of stain and decay in board cut from end log partially treated with filled hardened gloss oil and cresylic acid



THREE METHODS OF AIR-DRYING SAP GUM LUMBER

Even the best conditions of air-drying in open piles (A) will not prevent stain in damp weather, but an improvement here would have been a tight roof and the removal of the weeds. End racking with the stock crossed near the middle, as in (C), results in checks and warps in the upper half of the board before the lower half is dry enough to be removed. Crossing near the ends, as in (B), is better adapted for uniform drying and the prevention of end checking and warping, especially if a foundation raises the boards a foot or so off the ground the majority of manufacturers seemed to be that it was worth while to expend considerable effort in the prevention of stain.

The conditions that favor the development of stain in lumber, as in logs, are suitable temperature and a moist surface. It is impossible to control the temperatures in air-drying, but if the surface-moisture content of the stock can be quickly reduced to about 20 per cent, the chances are against the development of fungi to such an extent as to cause serious staining.[4] If the conditions are unfavorable for stain, they are likewise unfavorable for decay. Hence, if the operator can establish a condition which will eliminate the stain, he is practically assured that decay will not develop.[5]

AIR-DRYING

YARD PILING

The simplest and most common method of seasoning sap gum lumber is to run the green material straight from the chains to the yard pile. Fungus spores are always present in the yard, and if the drying is so slow that any portion of the surface of the board retains a relatively high moisture content for a considerable time, first stain and then decay will gain a foothold and develop.

The severity of fungus attack is governed to a great extent by local conditions. Mills located along the coast and in low river bottoms where rains are frequent and humidities high will suffer most. Many mills in the southern hardwood region that were able to yard dry their stock without material loss in the unusually dry summer of 1925 would not be able to do so in a normal year; and even in that year, mills along the coast suffered severe losses from stain and decay.

No system of yard piling will insure complete freedom from fungus infection. To obtain the best results from natural seasoning conditions, however, certain precautions should be carefully observed. The yard should be located on high or sloping ground, should be exposed to prevailing winds, should have good drainage, and should be free from weeds and débris. Foundations of piles should be firm and durable; piers should be constructed of concrete, creosoted wood posts or the heartwood of durable species such as cypress, white oak, redwood, or dense pine. Skids should be aligned to slope from front to rear about 1 inch per foot. They should be made of I beams, inverted railroad rails, creosoted timbers, or timbers of naturally durable wood all points of contact of which have been given two coats of hot creosote. The bottom of the pile should be at least 18 inches off the ground at the lowest point to allow free movement of air underneath. For sap gum the piles should not be more than 6 feet wide, and the space between adjacent piles should be at least 4 feet.

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[4] In some cases, where the surface dries very rapidly after infection has occurred, the fungi develop principally inside the board, giving rise to the so-called "interior blue stain."

[5] It was impracticable, owing to lack of time and funds, to study the effectiveness of chemical dips in controlling stain in lumber. It is known, however, that the dipping process is effective when properly used.

Avoid overhanging ends and the consequent bending and end checking of stock by piling boards of uniform length together. For uniform drying allow at least 2 inches between boards and a center flue 6 to 8 inches wide from bottom to top of pile. Stickers should be dry heartwood of oak or gum, seven-eighths by 2 inches, in alignment one above the other, and they should be spaced not more than 2 feet apart horizontally to prevent warping and cupping of stock. At the high end the pile should pitch forward about 1 inch per foot to keep rain from beating in.

A rain-tight roof is very important. The roof should project over the front and sides of the pile at least 8 inches and at the back at least 16 inches. The cover boards should be raised about 8 inches above the pile at the front and 2 inches at the back. Cover boards should be sound and tight and well lapped. The roof shown in Plate 6, A is an example of a covering that is more of a liability than an asset. It will not only fail to keep rain water out of the pile, but will prevent rapid evaporation, once the rain has entered.

END RACKING

Many operators end rack sap gum stock before piling it in the yard. In dry weather end racking permits very rapid surface drying and thus largely reduces the liability of the stock to stain during subsequent yard piling.

About August 1, in Merryville, La., 5/4 plain-sawed sap gum, after four days of end racking, had dried to an average moisture content of less than 35 per cent, some pieces containing only 20 per cent. This stock was end racked from five to seven days before flat piling. The surface moisture content of all boards had been reduced below the critical point (20 per cent) before the stain had a chance to start, and the lumber remained bright. Tests showed atmospheric relative humidities as low as 33 per cent during the daytime.

At Clarks, La., 4/4 sap gum was end racked for two days before flat piling, but some stain developed during the air-drying afterwards.

Where end-racked boards are more exposed at the top than at the bottom, they often check at the top before the bottom has dried sufficiently to avoid stain. If the lower ends are raised above the ground and well spaced, more uniform drying is obtained. Crossing the boards at the top, as illustrated in Plate 6, B is helpful in retarding drying and thus preventing end checking and is to be preferred to the system of crossing below the ends, illustrated in Plate 6, C.

If lumber is end racked too long it will warp severely, and if not racked long enough it will not dry sufficiently to prevent stain. End-racked stock must be carefully watched so that it can be taken from the rack just before warping begins. It should not be taken from the rack immediately following a rain, but should be left in place until the surface has redried. During wet seasons weather conditions become the controlling factor, and time on the rack must be adjusted accordingly. End racking is not expected to give as beneficial results in such periods as in dry seasons.

End piling (pl. 7, A) before regular piling in the yard is practiced to a limited extent, but as it does not permit as rapid drying as end racking, its use is limited to the drier parts of the country. When properly done, end piling gives better support to the boards than end racking and renders them less likely to warp or twist. Consequently the stock does not have to be watched so carefully, as there is no critical period which determines when it should be taken down for yard piling. In fact, at some plants it is left end piled until shipping dry.

STEAMING

At some mills it is the practice to steam sap gum before putting it out in the yard to dry. Steaming serves a double purpose. It sterilizes the stock, killing all fungous spores and any insects or larvæ present, and it conduces to rapid surface drying of the stock after removal to the air, thus reducing the hazard of reinfection. Also, it changes the color of the stock from white to pink, which is desired by some consumers. In patent steaming cylinders the period of steaming varies from 30 to 45 minutes and in specially built steam boxes from 4 to 24 hours, the temperatures in the latter reaching 180° to 212° F. In the cylinder live steam is used, and a pressure gauge on the supply line indicates pressures up to 20 pounds, but the pressure and temperature within the cylinder itself are not known definitely. In the steam boxes either live or exhaust steam may be used. High temperatures seem to cause checking in any red gum present with the sap gum, but at temperatures of 180° or less this checking is not so common. Two hours at 180° is probably sufficient to kill all fungi and larvæ of insects. From the point of view of seasoning, a four-hour steaming period at 180° seems to be as good as eight hours or longer, provided the stock is properly handled after it leaves the steam box.

Immediately after sap gum up to 6/4 in thicknesses has been steamed the doors should be opened, and as soon as the stock can be handled it should be pulled out and allowed to cool in the open for at least 48 hours before being bulk piled on the lumber buggies or trucks which take it to the yard. This treatment is too severe for 8/4 sap gum and flat-sawn red gum of all thicknesses above 4/4, as it is apt to cause surface checking. Such stock should be allowed to cool in the kiln to about 140° F. before the doors are opened; in other respects, it is handled as above indicated. Distortion, as shown in Plate 7, B, can easily be avoided by careful piling.

Rapid cooling dries the surface, and if the evaporated moisture is carried away rapidly the surface will be dried below the critical point sufficiently to prevent reinfection by the spores of the stain organism, which are always present in the air. When the cooled stock is taken from the kiln trucks it should be run out to the yard and repiled with as little delay as possible. If it is allowed to stand bulk piled on the buggies several hours after being removed from the kiln trucks, the surface will absorb moisture from the center of the stock, and the beneficial effect on surface-drying that results from the steaming process will be virtually lost. This remoistening of the surface is probably responsible for some of the blue or brown spots which are seen on steamed sap gum during subsequent yard drying. In other instances the spotting probably develops because the surface never became sufficiently dry after steaming.[6] This is likely to be the case if stock is pulled from the steam box on a damp day or if the trucks are stored so close together while cooling that the evaporated moisture can not be carried away rapidly.

At one of the mills visited, sap gum was run into a dry kiln and dried for 24 to 36 hours before being taken to the yard. No blue stain was found in any of the stock treated in this manner, presumably because the surface had dried below 20 per cent before the stock was piled.

KILN-DRYING

As there is an increasing demand for kiln-dried stock, many mills have been equipped with dry kilns in which yard-dry stock is seasoned to the moisture content specified by the buyer. Some manufacturers have experimented with the kiln drying of sap gum green from the saw, but the results have not been altogether satisfactory on account of degrade from warping and twisting and the relatively long time required in the kiln for each charge. Consequently few manufacturers are now attempting the complete seasoning of sap gum in the dry kiln. Nevertheless, sap gum can be and has been dried from the green condition with very low degrade. Success depends largely upon the skill and experience of the kiln operator and the use of suitable kiln equipment.

Kiln drying green from the saw is the best and, in fact, the only means of absolutely preventing stain and decay, as the drying is independent of weather conditions. Plain-sawed four-quarter sap gum can be kiln dried green from the saw to a moisture content of 5 per cent in about two weeks.

The following kiln schedule for stock up to 6/4 is recommended for cases where red gum or quarter-sawed sap gum is present with the plain-sawed sap gum:

Schedule 1

(Steam green stock four hours at 180° F. before drying is started)

Moisture content	Temperature	Relative humidity
Per cent	*° F.*	*Per cent*
Initial	135	80
40	140	75
30	145	70
25	150	60
20	155	50
15	160	35
10 to final	165	20

If the percentage of red gum or quarter-sawed sap gum is so small that it need not be considered, the following schedule is recommended:

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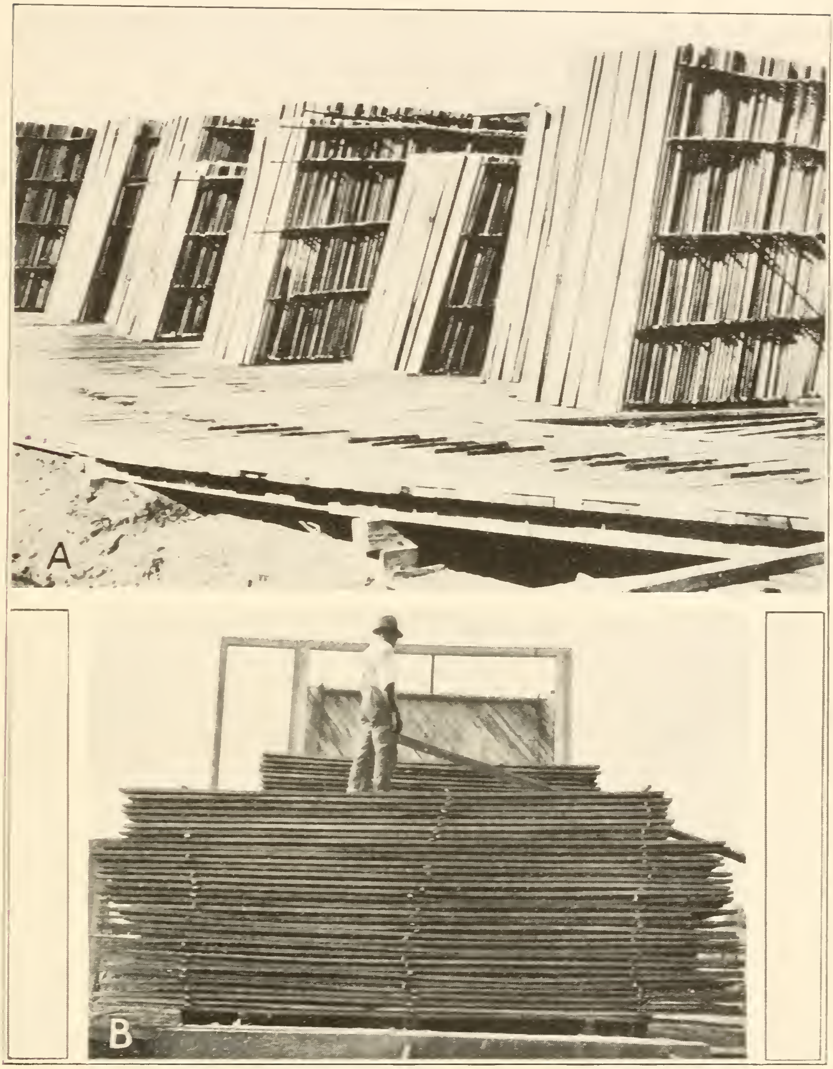
[6] Recent investigations at the laboratory indicate that the fungi which cause spot molding and staining of steamed lumber are different from those which cause blue stain of unsteamed lumber.



A.—End-piled Sap Gum

B.—Unloading Steamed Sap Gum

Misalignment of stickers has caused distortion of the stock in the steam box which yard-piling can not altogether remove

Schedule 2

(Steam green stock four hours at 180° F. before drying is started)

Moisture content	Temperature	Relative humidity
Per cent	° *F.*	*Per cent*
Initial	165	65
40	165	65
30	170	60
25	175	60
20	175	55
15	175	35
10 to final	175	25

COMPARATIVE TESTS OF SEASONING METHODS

As the field experiments progressed it became evident that no reliable comparison of the methods of seasoning sap gum lumber at different mills was possible because of differences in plant practice, climatic factors, and yard characteristics. Therefore a localized series of tests was started in 1925, with the object of obtaining direct comparisons of the various methods in common use and of a typical modification or alternative under each method.

The first three tests were made at Oakdale, La., and the fourth at Glenmora, La., 10 miles away, where a kiln was available.

The tests were as follows:

1. (*a*) End racking for three days, followed by yard drying. (*b*) End racking for six days, followed by yard drying.
2. (*a*) Yard drying in a "close" pile. (*b*) Yard drying in a very open pile.
3. (*a*) Steaming for four hours at 180° F., followed by yard drying. (*b*) Steaming for eight hours at 180° F., followed by yard drying.
4. (*a*) Rapid kiln drying for 48 hours, followed by yard drying. (*b*) Steaming at 180° F. for 12 hours, then kiln drying for 36 hours, followed by yard drying.[7]

The material tested was all of one thickness and grade, namely, 4/4 FAS sap. Throughout the period of the tests records were kept, from which the rates of drying obtained by the various methods could be determined and compared. The rate of drying was determined from five sample boards, each 2 feet long, so located in the pile as to represent as closely as possible the average drying rate of the pile. The samples were weighed daily the first 10 days. Afterwards, as the boards became fairly dry, they were weighed once a week for two months. A final weighing was given on the ninetieth day, marking the end of the test.

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[7] During the kiln-drying period a temperature of 165° F. and a relative humidity of 65 per cent were maintained as nearly as possible, corresponding to the initial stage of drying indicated in the second of the two schedules for gum given above.

ANALYSIS OF TESTS

Figure 1 shows how the drying rate of 4/4 stock was affected by the several methods described. For simplicity, the data for only one of each pair of alternative tests are plotted, inasmuch as the differences between the alternative tests were relatively slight.

Little difference appears in the rate of drying as between the stock that was in the kiln 48 hours and the stock end racked six days. The stock that was steamed eight hours did not dry so rapidly during the first six days. But after 16 days the stock in all three of these tests had reached a common moisture content. The last weighing showed the important fact that all three lots were as dry after 30 days in the yard as after 90 days.

Straight yard drying proved to be very much slower than any of the other methods, particularly for the first six days. During this period there were some light showers, but the weather was generally bright, clear, and reasonably good for drying. It appears that the rate of yard drying is especially sensitive to adverse conditions when no preliminary treatment has been given. About 18 days after piling there were again several days of wet weather, the effect of which shows itself prominently in the curve for yard drying alone and to a much less degree in the other curves. It is probable that the retardation of drying in the yard stock was due, in part at least, to retention of moisture by heavy mold growth on the surface of the boards.

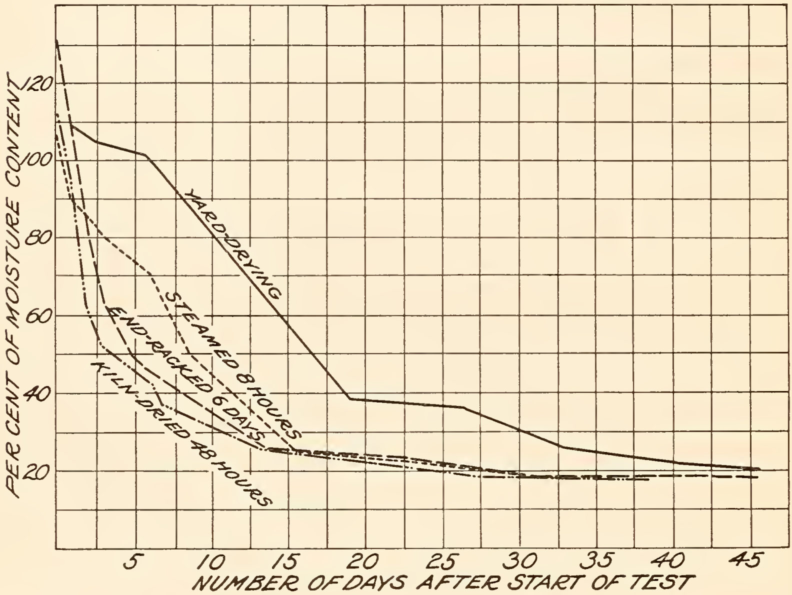

FIG. 1.—The drying rate of four-quarter sap gum when simply yard dried and when yard dried after being subjected to preliminary treatments

At the completion of the tests the lumber was taken down and carefully graded, and the causes of all degrades were noted. For simplicity, selects were grouped with No. 1 common to form a single grade, according to practice sanctioned by hardwood grading rules. Tables 1 to 4 show the percentages of stock on grade and free from stain, of stock on grade but stained, and of stock lowered in grade, and the cause of the degrade, for the respective seasoning methods studied.

As a means of preventing stain and decay, end racking for three days showed as good results as end racking for six days (Table 1). It was quite evident that the surface moisture content had been reduced below the critical point in three days or less. The greater amount of warping and checking found in the stock that had been end racked three days can be accounted for by the manner in which it was piled after racking. The pile containing this stock was about 30 inches higher than the others in the yard and hence more exposed at the top to wind and weather. Also, there were a number of displaced stickers in the upper layers. Most of the checked and warped stock was found at or near the top of the pile. Other things being equal, it is evident that end racking for three days will not produce more degrade of this type than end racking for six days, but rather the reverse.

TABLE 1.—*Seasoning of 4/4 firsts and seconds sap gum; results of end-racking followed by yard-drying*

Method of seasoning	Stock on grade, or cause of degrade	Final grades		
		Firsts and seconds	No. 1 common	Waste
		Per cent	*Per cent*	*Per cent*
End-racked 3 days, yard-piled 90 days	On grade, not stained	82.3		
	On grade, stained [1]	1.6		
	Rips and cuts	4.0		0.55
	Checks		[2] 6.3	
	Warp		[2] 5.0	
	Decay		0.25	
Total		87.9	11.55	.55
End-racked 6 days, yard-piled 90 days	On grade, not stained	93.0		
	On grade, stained [1]	1.9		
	Rips and cuts	1.0		.1
	Checks		2.1	
	Warp		1.6	
	Decay		.3	
Total		95.9	4.0	.1

[1] Stain in sap gum is not recognized as a defect by hardwood grading rules.

[2] Most of this loss was due to yard piling and not to the method of end racking.

Practically all the stock that went into the yard piles direct from the chains was found to be very badly stained, and many boards were decayed. (Table 2.) It was intended that these two piles should demonstrate the relative merits of open and close piling, but the result was inconclusive in that respect. In one pile the boards were separated 2 to 4 inches, and two flues 6 inches wide extended from the top to the bottom of the load. The other pile was laid up with boards 1 to 2 inches apart and with only one 6-inch flue. It happened, however, that the pile with more open spacing and two flues was erected between two standing piles, whereas there was a vacant space on one side of the close pile for a week or more after it was erected. The close pile contained less stained stock than the open one. Most of the unstained boards in the close pile, as would be expected, were found on the side adjacent to the vacant space.

TABLE 2.—*Seasoning of 4/4 firsts and seconds sap gum; results of yard-piling green from the saw*

Method of seasoning	Stock on grade, or cause of degrade	Final grades		
		Firsts and seconds	No. 1 common	Waste
		Per cent	*Per cent*	*Per cent*
Air-drying, 2 flues in pile	On grade, not stained	7.86		
	On grade, stained [1]	77.98		
	Rips and cuts	1.38		0.19
	Checks		2.51	
	Decay		7.63	
	Worms		2.45	
Total		87.22	12.59	.19
Air-drying, 1 flue in pile	On grade, not stained	11.54		
	On grade, stained [1]	76.0		
	Rips and cuts	1.7		.24
	Checks		5.93	
	Warp		3.05	
	Decay		1.54	
Total		89.24	10.52	.24

[1] Stain in sap gum is not recognized as a defect by hardwood grading rules.

Steaming proved very efficacious in reducing stain and decay. It is true that most of the steamed stock had blue spots, rather scattered and small on the eight-hour stock, but close and large on the four-hour stock. This stain was only on the surface, however, and would dress out when the stock was planed. The lumber inspector, when grading this stock, tallied the pieces with large spots as "stained" and those with very small scattered spots as "unstained." The grading data are shown in Table 3. Only a few boards were badly stained. They were found at or near the top of the piles, and their condition resulted from leakage through the covering boards.

TABLE 3.—*Seasoning of 4/4 firsts and seconds sap gum; results of steaming followed by yard-drying*

Method of seasoning	Stock on grade, or cause of degrade	Final grades		
		Firsts and seconds	No. 1 common	Waste
		Per cent	*Per cent*	*Per cent*
Steamed 4 hours at 180° F. and yard-piled for 90 days.	On grade, not stained	37.0		
	On grade, stained [1]	56.6		
	Rips and cuts	.96		.13
	Checks		3.04	
	Warp		[2] 1.34	
	Decay		.93	
Total		94.56	5.31	.13
Steamed 8 hours at 180° F. and yard-piled for 90 days.	On grade, not stained	97.79		
	On grade, stained [1]	.40		
	Rips and cuts	.36		.06
	Checks		.53	
	Warp		.43	
	Decay		.43	
Total		98.55	1.39	.06

[1] Stain in sap gum is not recognized as a defect by hardwood grading rules.
[2] Attributed in part to faulty stickering in the steam box.

The prevalence of the spot stain indicates that the steamed stock had not surface-dried quite enough before it reached the yard pile; this inference is supported both by the drying records and by conditions attending the cooling of the lumber. The steam boxes at the Oakdale plant are arranged for cross piling, and when the freshly steamed stock is moved out of the boxes the cars are set close together on the tracks. Circulation through the lumber is thus restricted. Also, as the tracks will hold only one charge, the cars are unloaded daily. If the steamed lumber could stand on the cars for 48 hours or more and the cars be well separated and exposed to a good circulation of air, there is reason to believe that all staining would be prevented.

Although in all the tests most of the warping and cupping was found near the top of yard piles, poor stickering in the steam box was found to be the cause of a certain amount of warping at various points in the piles of steamed stock (pl. 7, B). While for simple steaming it may not be necessary to use stickers 18 inches to 2 feet apart, as it is in kiln drying, it is essential that the sticker rows be carried up in vertical alignment.

There was no important difference in either degrade or drying time between the stock steamed for 12 hours and kiln dried for 36 hours and the stock kiln dried for 48 hours. Table 4 gives the grading data. In both cases all of the stain was in the upper part of the pile and was caused by a leaky roof.

TABLE 4.—*Seasoning of 4/4 firsts and seconds sap gum; results of kiln treatment followed by yard-drying*

Method of seasoning	Stock on grade, or cause of degrade	Final grades	
		Firsts and seconds	No. 1 common
		Per cent	*Per cent*
Steamed 12 hours, kiln dried 36 hours, and yard piled 90 days.	On grade, not stained	92.80	
	On grade, stained [1]	6.89	
	Checks		0.31
Total		99.69	0.31
Kiln-dried 48 hours and yard piled 90 days	On grade, not stained	96.38	
	On grade, stained [1]	3.07	
	Checks		0.55
Total		99.45	0.55

[1] Stain in sap gum is not recognized as a defect by hardwood grading rules.

Such slight decay as was found in the end-racked, steamed, and kiln-dried stock was caused by sticker rot. This did not develop sufficiently in the kiln-dried stock to be a cause of degrade. In the pile air-dried only, on the other hand, many boards were found having large areas in an advanced stage of decay.

A roof over the pile which will shed water is essential in preventing stain, regardless of whether the stock has been end racked, steamed, or kiln dried. The roofs over the test piles did not shed rain water successfully. Obviously, stock which has been carefully handled before going into the yard pile should not be put in jeopardy by a poor roof.

CONCLUSIONS

Spray treatments of gum logs with cresylic acid mixed with kerosene or crude oil, although without influence on checking, proved effective in preventing decay and greatly retarded the spread of stain for periods of five weeks of hot summer weather and three months of late summer and fall weather. During the same periods untreated logs were severely stained and infected with decay. A coating of hardened gloss oil and cresylic acid on log ends prevented decay and reduced stain but failed to warrant the extra labor and expense of application, as it lacked sufficient body to retard the end-checking to any marked extent. A filled hardened gloss oil and cresylic acid mixture was very effective in reducing end-checking, and it also appeared to give better results than the other mixtures in controlling stain.

Stain which enters the log through abrasions in the bark penetrates across the grain rather slowly, and can usually be slabbed off unless the logs are stored for long periods. If long storage—say two months of summer weather—is anticipated, the sides should be sprayed with a cresylic acid mixture or other suitable antiseptic.

In the yard-seasoning experiments the sap gum stock that was run direct from green chains to the yard and piled in the most approved manner (open piled with two flues; pile foundations at least 18 inches off the ground at the lowest point) dried too slowly to prevent stain and decay. In normal years this condition would obtain in many, perhaps in most, yards. End-racking, steaming, or partial kiln-drying before yard-piling will, if properly done, prevent the subsequent occurrence of stain and decay, provided the stock is kept dry in the pile.

Of the three methods involving preliminary treatment before yard drying, no one seems to have a marked advantage over the others so far as stain and decay are concerned. During a period of protracted wet weather, end racking can not be expected to give as good results as in dry weather. Also, since end-racked stock must be watched carefully and taken down before warping starts, this method is sometimes difficult to handle properly in very dry weather. As a general proposition, the steaming and partial kiln-drying methods are probably less influenced by weather than is end racking, although wet weather can interfere with the handling of the steamed or kiln-dried stock also. The kiln treatment shows slightly better results as to total degrade than do the other two methods.

Where operating conditions make it practicable, kiln drying sap gum lumber green from the saw to the final moisture content desired will prevent stain and decay and can be accomplished in about two weeks. Skill and experience are necessary to kiln-dry gum satisfactorily on account of its tendency to warp and twist.

Prevention of stain and decay in sap gum lumber without using antiseptic dips is dependent upon (1) drying the surface to the point where the spores can not develop, and (2) keeping the surface dry afterward. It is unimportant which method (end-racking, steaming, or partial kiln drying) is used if it accomplishes the purpose.

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July 9, 1927

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